# AUTOMATED SYSTEM DEVELOPMENT AND DOCUMENTATION CRITERIA

GEORGE V. ZEBERLEIN

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Lieutenant Commander, United States Navy

Submitted in partial fulfillment of
the requirements for the degree of

MASTER OF SCIENCE

IN

MANAGEMENT (DATA PROCESSING)

United States Naval Postgraduate School
Monterey, California

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ABSTRACT

The use of standard procedures in development and documentation of automated systems has become a necessity. Many activities in Government and industry are expending a large effort in manpower and costs in duplicating procedures and documentation that may have been prepared many times before. An effort has been made in this paper to describe an approach to a standardized system of development and record keeping that would preclude duplicating effort previously expended in the same area.

The paper follows the development of an automated system from its inception to completion recommending methods for recording procedures used in automating a functional process.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

# CHAPTER I

## A. INTRODUCTION

In developing an automated system, whether it be military or commercial, the proper planning, analysis and design is dependent upon adequate data, systematically developed and properly documented. The purpose of this paper is to present the logical development of an automated system from its inception to completion. Emphasis will be placed on proper and timely documentation requirements.

Thousands of automated systems have been and are being designed by government and industry. Computers are becoming continually more sophisticated and the output (reports, display, etc.) of these automated systems are extremely well developed. The "State of the Art" for automated systems had advanced much more rapidly than its administrative development and documentation. In other words, we have ultramodern systems and archaic methods of administrative control and record keeping. Part of the reason for this is the lack of glamour to this extremely necessary segment of development. It may never be glamorous, but it must be performed, else we build on a foundation of sand.

Two major questions arise in administrative development and documentation. These are, who should control this development and how must it be controlled.

In a recent Senate Report to the President on "...The manage-

ment of Automatic Data Processing in the Federal Government" [1]

Many of the problems in the field of Data Processing Management were discussed. It outlined the problem of who should control administrative development as follows:

> The assignment of appropriate roles to the different echelons of management in the Federal Government is of great importance. Some computer applications, particularly those involved in administrative functions; have a great deal in common and conceivably could be subject to greater centralization. On the other hand, the more significant computer applications are integral parts of agency programs; accordingly, each is a unique application and its management is a responsibility of those officials charged with mission accomplishment. The problem then becomes one of improving the effectiveness and the economy of computer utilization, both within an executive agency and in the government as a whole, without derogating the proper authorities and responsibilities of managers in the line.

This problem has not gone unnoticed in that the report provides for some macro-type solutions by recommending that:

> 1. The Bureau of the Budget will develop a broadly based program of continuous evaluation of computer systems, to provide an assessment of accomplishments and to serve as a recurring source of information for the development or revision of policies and guidelines. The responsibility for conducting evaluations and preparing appropriate reports will rest with the agency heads, in accordance with their normal management responsibilities.
> 2. The Bureau of the Budget will develop criteria to assist in evaluating both systems design and various aspects of system performance.
> 3. Agencies should develop master data-processing plans at appropriate levels, to serve as guides in the orderly development of systems and to assure the most effective use of staff resources available for that development.
> 4. The Department of Commerce, through the National Bureau of Standards, should expand the advisory service currently being provided to agencies in the analysis and design of computer-based systems. Its resources allocated for this purpose should be increased to the extent required to meet such needs as fully as possible.

The report also emphasizes the necessity of managers to concern

themselves with all aspects of Data Processing from the determination of objectives to the utilization of the end product.

One of the major concerns of the data processing manager is that of documentation criteria and documentation standards. Recognition of the importance of these problems is emphasized in the Senate report in that two of the twelve major actions alluded to them - i.e. - action number 7 and 12 noted below.

> #7. Strengthen Government support of programs initiated by the American Standards Association to achieve needed compatibility among automatic data processing equipment and systems.
>
> #12. Propose the enactment of legislation by Congress which would: . . .
> (b) strengthen the authorities for the development, testing and implementation of standards; the Performance of Research in computer sciences and the provision of advisory services by the National Bureau of Standards.

Standardization is described by Dr. Otto Frank[1] as

> The regularization or establishment of what is approved as good or valuable. It aims to reduce the uncoordination, confusion and waste that ensue from a needless variety of products or methods, and to discourage the persistence of practices which experience has shown to be less good than the best.

In other words, use procedures that are generally accepted in the field of management and data processing. How does one know what is generally accepted as being "Good or Valuable?" The answer to the question has not been fully considered, however: The Federal Government is now vitally interested in the answers. A step toward an acceptable answer is being made as a result of the above mentioned Senate Report which states in part:

[1]Frank, O., Modern Documentation and Information Practices, International Federation for Documentation, 1964, 1.

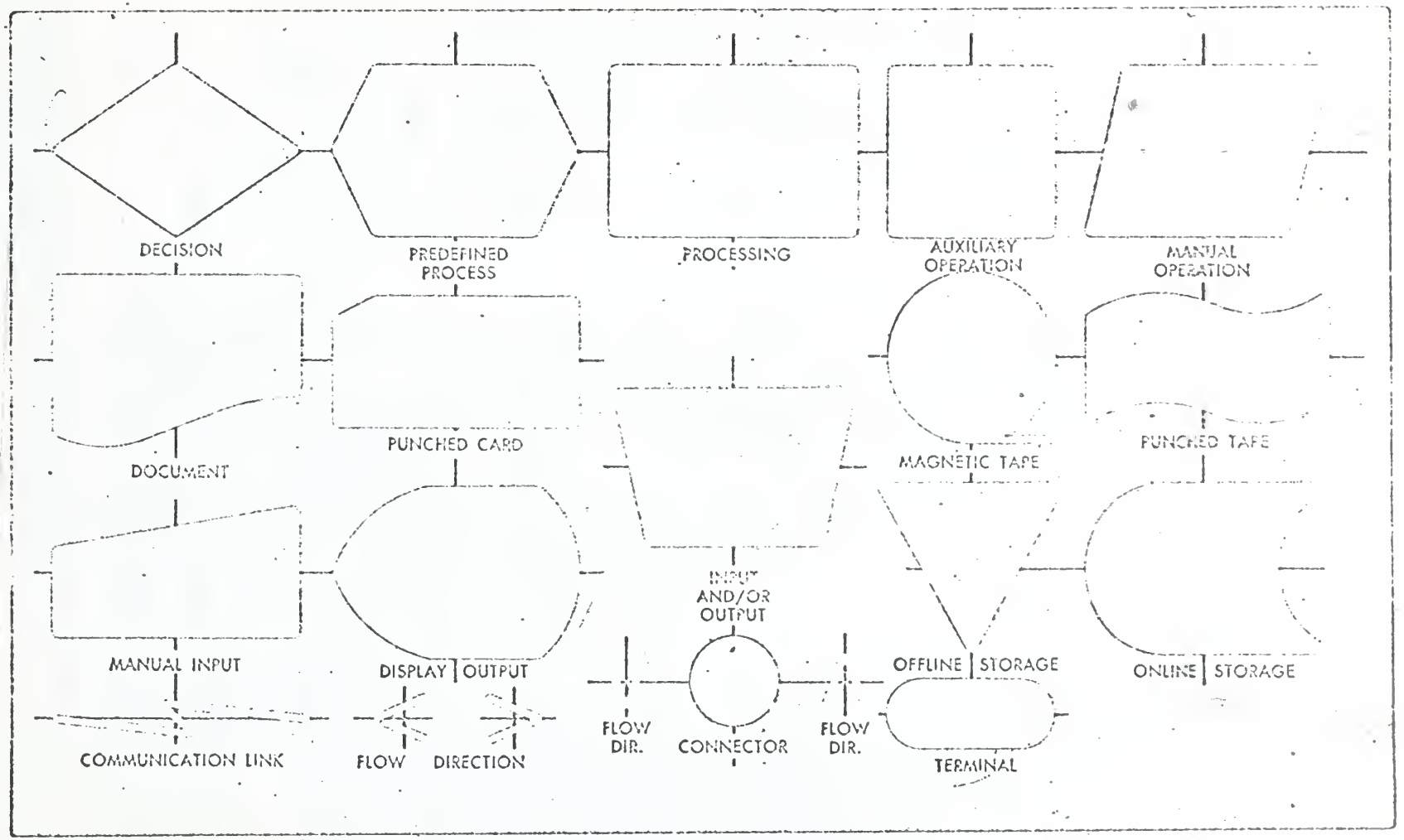

DECISION
PREDEFINED PROCESS
PROCESSING
AUXILIARY OPERATION
MANUAL OPERATION
DOCUMENT
PUNCHED CARD
MAGNETIC TAPE
PUNCHED TAPE
MANUAL INPUT
DISPLAY
OUTPUT
INPUT AND/OR OUTPUT
OFFLINE
STORAGE
ONLINE
STORAGE
COMMUNICATION LINK
FLOW DIRECTION
FLOW DIR.
CONNECTOR
FLOW DIR.
TERMINAL

Figure 1

> A related problem (to compatability of computer systems) is the lack of standardization of data elements in common use and the codes used to represent those elements. ....Today, the close interrelationship among systems of different agencies or the centralized summarization of data common to all agencies, demands that data elements or codes representing an element of data be standard for the Government." [2]

In one area of standardization, that is the area of flow charting automated systems, the Department of Defense has developed standard flow charting symbols. Figure 1 displays these standard symbols.

An example of where the problem of lack of standardization exists is the area of command and control in the Department of Defense. The Army, Navy, and Air Force each have their own method of preparing documents. There is some effort to develop standard programming techniques and language through joint standardization committees within the Department of Defense. However, there is a great deal still to be accomplished in the area of documentation standards. The Army developes the majority of their automated programs "in house" without the use of contractor assistance. The Navy uses a combination of "in house" effort and contractor assistance. The Air Force uses mainly contractor effort in development.

A more detailed look at both problems of "who" and "how" has been well developed by John T. Garrity[2] in an article describing a study conducted by McKinsey & Company on the experiences of twenty-seven major companies in 13 different industries.

These companies have invested on the aggregate over $100 million a year in automation and all have had at least four years

[2]Garrity, J. T., Top Management and Computer Profits. Harvard Business Review, July-Aug 1963, 6.

computer experience.

The survey sought to discover each company's opinion on the success of the venture based on the criteria of:

1. Dollar Return from computer system investment.

2. Long term indirect benefits.

3. Range and scope of applications currently using the computer.

The results were quite decisive. The companies fell into two distinct groups; a group of nine had very successful results and a group of eighteen whose results were marginal at best. There were none that were moderately successful.

In order to isolate the basic factors that determine the successful operation, the survey used six areas of investigation for a comparative analysis. These areas were:

1. The quality of executive leadership provided for the computer systems effort.

2. The soundness of planning and control tools used in managing the effort.

3. The degree of operating management involvement.

4. The caliber of the computer systems technical staff.

5. The role of the corporate computer systems staff.

6. The equipment strategy.

In each area the question and responses were divided into two categories; those responses which reflected major differences between the successful and unsuccessful companies and those responses which reflected basic similiarities.

Mr. Garrity concludes that there were eleven major differences between the successful and unsuccessful companies.

In the successful companies the executive management devoted a reasonable proportion of their time to the computer system, subject to its cost and potential in relation to other executive responsibilities. This did not mean that they were involved in the technical aspects of development, but in the management problems involved in integrating the computer system with the management process. This means they spend time reviewing plans and progress and insure that proper results are achieved.

Before any application is initiated in the successful company a careful feasibility study is conducted to insure that the application is cost effective and practical. Once a project is initiated, project development and progress is followed closely by the corporate management including the chief executive. These leading company executives were continually looking for methods to strengthen their management control over the computer systems effort.

In the area of operating management involvement in the computer systems effort there appeared the greatest divergence between the two classes of company.

The lead company's operating management took a very active role in the selection, planning and manning of the projects undertaken. This appears to be due to several factors, including top management's attitude of fostering effective staff-line relation-

ship and an atmosphere favorable to an innovating, inquiring approach. In addition, top management has clearly defined the operating executives role in the computer system effort.

The role of the technical staff is very clearly defined by the executive leadership of the lead companies. The need for a competent and well staffed technical capability was recognized. These companies not only provided this but further supplemented their systems skills by including management-sciences personnel on the staff.

Each successful company in general, provided a computer executive who could function effectively with limited technical knowledge at the first or second level below the chief executive and a computer systems manager who had extensive technical skill at the next level below the computer executive. This appeared to provide sufficient technical effectiveness with proper management control.

In general, the lead companies, placed the computer system organization in the corporation at the division level with as little disturbance to the company organization as possible. This, however, did not seem to be a major factor in the success of the company's effort.

It is also noteworthy that all the companies, successful and unsuccessful tended to have the same equipment strategy.

The overall basic factors derived from the survey appear to show that top management must correctly assess the computer's potential and provide the continuing management guidance that it

requires.

We must therefore conclude that the answer to "Who" part of the question of control is that all management from the chief executive to the operating and technical staff must take a active role in the operation with top management taking a lead role. The answer to the "How" part is much the same, top management taking an active part in establishing policies and guidelines and the close cooperation of the operating and technical staffs in carrying them out.

## B. OBJECTIVE

It is the intention of this paper to describe the functional steps in the development of an automated system and delineate the documentation required.

The logical sequence of events in this development are: Planning, Analysis, Development, Evaluation and Operation of the System. Planning will include the problem definition and study to determine the feasibility of the solution. Analysis is the detailed study which determines the method of solution of the problem. Development would be the program preparation. Evaluation can be considered the test to determine if the solution to the problem is correct and adequate. Operation is using the system as designed. Each will be considered and the documentation requirements for each phase will be outlined.

In the development of an automated system, the first consid-

eration must be given to the type of unit that will perform the development. This unit may be internal to the organization requesting the development such as the computer system division of a activity or may be an external activity contracted to perform the automation such as commercial commercial consulting firms. In either case the unit performing the development must be properly and adequately staffed. This means the proper mix of systems analysts, operations analysts, system programmers, and technical writers with adequate experience in the field of program development. Obtaining such a qualified group may be a major problem since these type of skills are in great demand. One consulting firm known personally to this author has a policy that it will hire only individuals who can substantiate five years experience in their respective field. It is assumed for the purpose of this paper that this important function is available and competent.

## CHAPTER II

## PLANNING

The planning phase of the development can be considered the problem definition and problem analysis phase. It consists of the system requirement development (determination of the problem), the design study (problem definition and analysis) and the design review and approval. The system requirement is generally determined by the activity or organization desiring automation of a function (hereafter called the user or user activity). The unit or activity performing the analysis and programming will be known as the developer or developing activity.

### A. THE SYSTEM REQUIREMENT

The initiation of an automated system will be by users recognizing that their present method of operation is inadequate, inefficient or ineffective. The question that usually starts a new approach is: "Isn't there a better way?" The answer is usually - Yes.

The general context of the example given in this paper will be that of a Naval activity, however, the same basic problems and solutions will arise in almost any field.

The system requirement document must provide a clear and concise explanation of the problem. It must define the objectives of the system and describe in detail the present method of oper-

ation. It must describe the present deficiencies, the data available and the desired goals, including when the new capability is required.

A description of the requirement is a vital part of the system analysis and care must be taken that adequate information is provided to insure that the correct problem is analyzed and solved. The user prepares this document without the assistance of the developer. This is done to insure that only the users concept of the problem establishes the requirement since he is generally oriented functionally and is able to define the problem that he wishes solved. If the assistance of the developer is used there is the possibility of distortion of the problem to fit the developer's preconceived concept of operation. Thus, the requirement document must contain the requestor's concept of operation providing a non-technical description of the capability required and specifying what tasks are desired. These tasks refer to the various phases of development of the automated system. This may range from a feasibility study to the complete analysis and implementation of the system.

This requirement document must contain an identification number or code that will indicate the activity requesting the project. This may be an internal or external activity. As an example, there may be requests from the control division or the Technical division of the activity performing the function of automating or from an external activity. Each may be assigned

a code for identification and cross reference. A code that indicates the classification of the function, such as, operations, Intelligence, communications or logistics should also be assigned. Any system of identification and ready reference would be acceptable if it insures clear, concise classification. The method described above is currently in use in the Naval Command and Control System. It provides a two digit code for the requesting activity, a single letter code for the functional area and a serial number indicating time of receipt. An additional code could be used for priority classification.

A noun title would usually be assigned for ease of nonautomated reference.

In addition, the priority and date capability is required must be included. These factors will assist in determining the feasibility, timeliness and appropriateness of the project.

## B. DESIGN STUDY

Upon receipt of the system requirement by the systems analysis group, a design or feasibility study is conducted. This study should be conducted in close liasion with the user.

The study group will analyze the requirement in detail, defining the present system, the data inputs, the data formats, detail processing being conducted, output data and form of presentation.

A definition and explanation of the present activity's

responsibilities and the desired capabilities to be provided by the new system must be made.

An analysis will then be made of the organizational relationship within the activity by the use of information flow analysis including all interactions within the activity and with all concerned parties outside the activity. Information flow analysis concerns itself with data and document transmission without considering organizational structure. It is a derivation of pert analysis on documents and data.

Problem areas such as duplication, dual responsibility and inconsistencies will be described.

A comparison will be made of the organization functional procedures with the information flow analysis to clarify differences and provide background for recommended revisions.

This may also be called a systems analysis. It involves collecting, organizing, analyzing and evaluating the pertinant facts about the present system and its environment. This is accomplished by determining the input and output requirements of the present system, the sources of data, the method of processing, (eg. ADP, EAM Manual, etc.) the frequency and volume of the data transactions.

Now for the development of a new system, the systems analyst must be fully cognizant and responsive to acceptable standards of procedure. The analysis is conducted by the developer with the cooperation of the user staff.

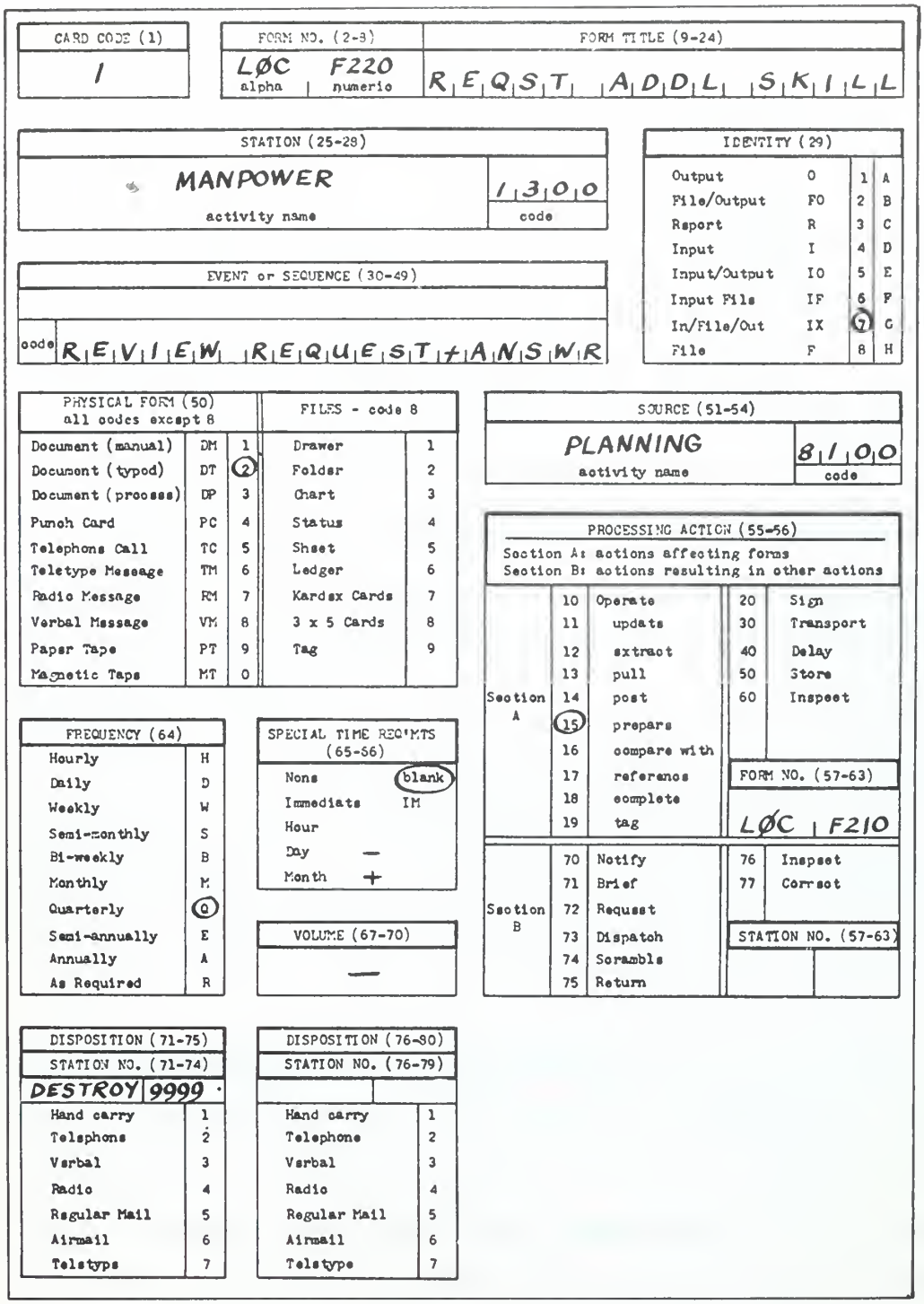



**Figure 2** . *Message specification sheet.*

The most generally accepted method of conducting an analysis involves the following series of logical steps:

First, the facts or data must be assimilated. This is done by interviewing personnel and observing activities performed in the system.

Second, obtain sample copies of all data inputs and outputs - i.e. documents, files, including statistics and processing time, frequency and volume encountered during the operation.

Third, learn the processing operations and determine how and why each item in the system is processed.

Fourth, organize the data obtained into a systematic and logical flow, noting redundancies, overlaps, duplication, omissions, and the development of new concepts proposed or informally initiated by the user personnel.

Fifth, review the data obtained with the personnel involved to determine if data is correct and flow developed is a true representation of this data. The key to successful completion of these five steps is complete and clear documentation as illustrated below:

Document Specification and Disposition Form. This is a standardized form for presenting detailed specification and disposition of any communication. It provides a sequence number for integration into the flow analysis. The form is of a general nature therefore may be used by virtually all analysts for all types of communications. It provides a card code, form number, and title for identification

and cross reference. The analyst prepares this form as he is interviewing personnel responsible for preparation and disposition of the document under consideration. He identifies the activity currently processing the document, the processing action, the physical form, the frequency of processing and disposition. With this form he is able to follow the sequence of actions on each document within a specific activity or follow any document as it is processed by each activity.

Figure 2 is an example of this form. The document is a "request for additional skill" from the planning department to the manpower department. As indicated the manpower section must prepare a typed answer. This action is done on a quarterly basis. There is no special time requirements on the action.

This form, along with a completed copy of the document provide the input data for the system analysis. The forms and copies of documents are edited, summarized, analyzed and flow charted to provide a comprehensive, quantified understanding of the data flow throughout the organizational area being considered.

The conclusions from this analysis will provide documentation on location characteristics and relationship, file analysis, network and location load analysis, document activity analysis, and flow analysis.

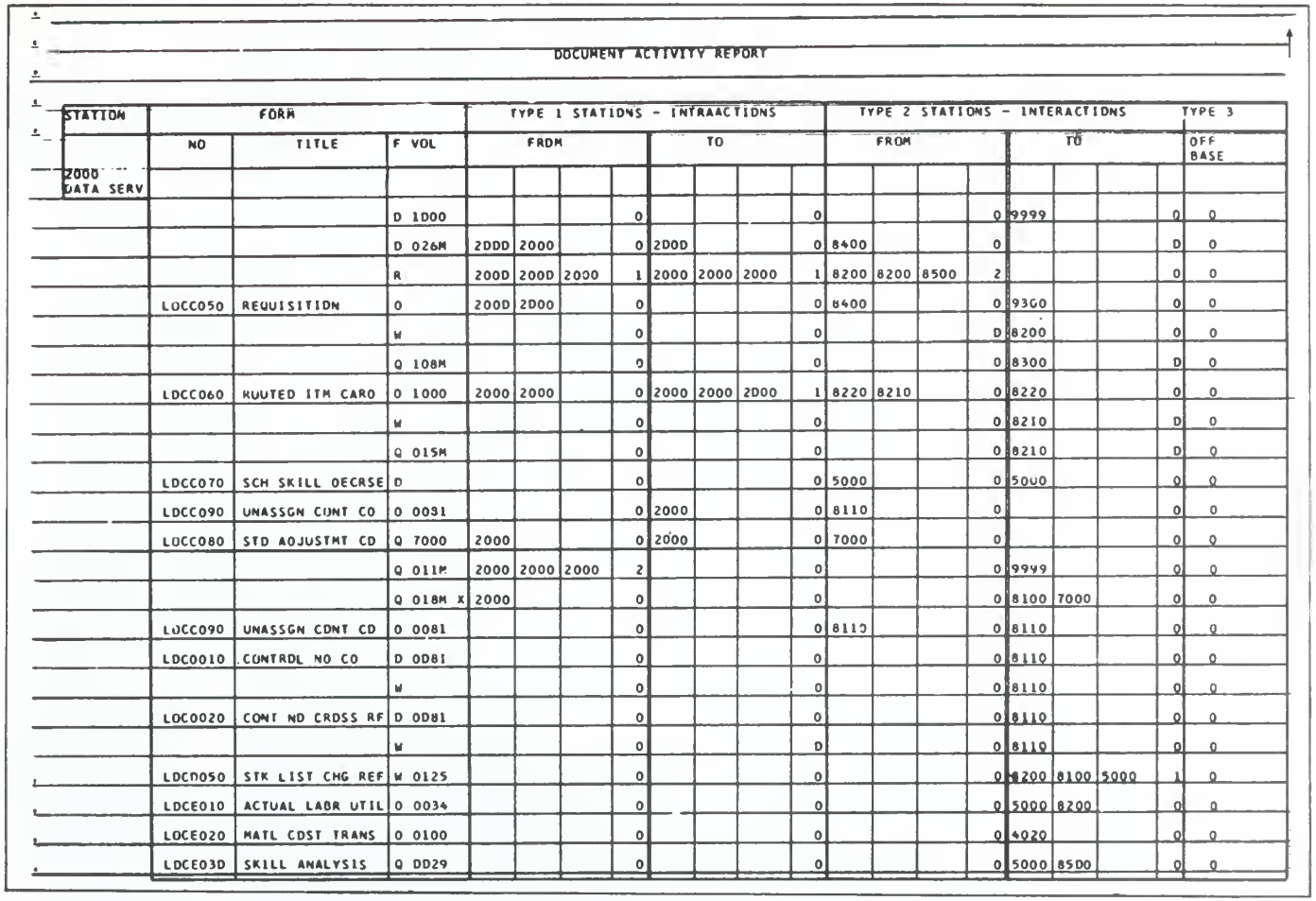
Location Characteristics and Relationships. This documentation will include description of files and the type, frequency, volume and special requirements of the data processes at the location. It

NETWORK DATA LOAD DETAIL REPORT

| STATION CODE | STATION NAME |
|---|---|
| 4000 | COST ACCTG |

| IO | FREQ | SPEC TIME REQ | DOCUMENT, FORM, REPORT NO. | TITLE | PRESCRIBING DIRECTIVE | VOLUME FREQ | MONTHLY | H | PERCENTS OF TOTAL MONTHLY VOLUME IO VOL | H | O | W | SM | BW | M | Q | SA | A | AR | SPEC TIME IM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | M | | LOC 108 | OM OP COST REPT | | 01 | 1. | 1 | | | | | | | | | | | | |
| 2 | M | | LOCF012 | OCR OM LBR HOURS | | 01 | 1. | 1 | | | | | | | | | | | | |
| 2 | M | | LOCF014 | OCR OPEH ANALYS | | 01 | 1. | 1 | | | | | | | | | | | | |
| 2 | M | | LOCF130 | OCR BUO VAR SCHO | | 01 | 1. | 1 | | | | | | | | | | | | |
| 2 | M | | LOCF140 | OCR OM GEN EXP | | 01 | 1. | 1 | | | | | | | | | | | | |
| 2 | M | | LOCF150 | OP COST REPT/BR | | 05 | 5. | 1 | | | | | | | | | | | | |
| 2 | M | | LOCF160 | OCR OM SUMM | | 01 | 1. | 1 | | | | | | | | | | | | |
| 2 | M | | LOCF170 | OCR SHOPS OIV | | 01 | 1. | 1 | | | | | | | | | | | | |
| 2 | M | | LOCF175 | OP COST REPT/WC | | 34 | 34. | 1 | | | | | | | | | | | | |
| 2 | M | | LOCF232 | OCR SHOP GEN EXP | | 01 | 1. | 1 | | | | | | | | | | | | |
| 2 | M | | LOCF234 | OCR MATL VAR | | 01 | 1. | 1 | | | | | | | | | | | | |
| | | | TOTAL | | | | 48. | | 1.86 | | | | | | | | | | | |
| 6 | B | | LOC 130 | ACT PAYROLL LIST | | 34 | 74. | 1 | | | | | | | | | | | | |
| 6 | M | | LOC 107 | EARNED HR ANAL | | 01 | 1. | 1 | | | | | | | | | | | | |
| 6 | M | | LOC 131 | ACT EXPENDTR LST | | 01 | 1. | 1 | | | | | | | | | | | | |
| 6 | C | | LOCA240 | WORK REQUEST | | 25 | 525. | 1 | | | | | | | | | | | | |
| 6 | E | | LOCE100 | END ITEM COST RP | | 10M | 1667. | 1 | | | | | | | | | | | | |
| 6 | M | | LOCE190 | MTCE COST SUM/MO | | -0 | 0. | 1 | | | | | | | | | | | | |
| 6 | E | | LOCE191 | MTCE COST SUM/SA | | -0 | 0. | 1 | | | | | | | | | | | | |
| 6 | M | | LOCE250 | MATL IN MTCE | | 29 | 29. | 2 | | | | | | | | | | | | |
| 6 | W | | LOCE300 | MATL VAR ANALY | | 34 | 147. | 2 | | | | | | | | | | | | |
| 6 | M | | LOCE440 | STD + ACT LABOR | | 34 | 34. | 1 | | | | | | | | | | | | |
| 6 | M | | LOCF012 | OCR OM LBR HOURS | | 01 | 1. | 1 | | | | | | | | | | | | |
| 6 | M | | LOCF014 | OCR OPEH ANALYS | | 01 | 1. | 1 | | | | | | | | | | | | |
| 6 | Q | | LOCF075 | MO DIST/APRV BUO | | 12 | 3. | 1 | | | | | | | | | | | | |
| 6 | M | | LOCF130 | OCR BUO VAR SCHO | | 01 | 1. | 1 | | | | | | | | | | | | |
| 6 | M | | LOCF140 | OCR OM GEN EXP | | 01 | 1. | 1 | | | | | | | | | | | | |
| 6 | M | | LOCF150 | OP COST REPT/BR | | 05 | 5. | 1 | | | | | | | | | | | | |
| 6 | M | | LOCF160 | OCR OM SUMM | | 01 | 1. | 1 | | | | | | | | | | | | |
| 6 | M | | LOCF170 | OCR SHOPS OIV | | 01 | 1. | 1 | | | | | | | | | | | | |
| 6 | M | | LOCF175 | OP COST REPT/WC | | 34 | 34. | 1 | | | | | | | | | | | | |
| 6 | M | | LOCF232 | OCR SHOP GEN EXP | | 01 | 1. | 1 | | | | | | | | | | | | |
| 6 | M | | LOCF234 | OCR MATL VAR | | 01 | 1. | 1 | | | | | | | | | | | | |
| | | | TOTAL | | | | 2528. | | 98.14 | | | | | | | | | | | |
| F | Q | | LOCE260 | MATL STD COST LS | | -0 | 0. | 2 | | | | | | | | | | | | |
| | | | TOTAL | | | | 0. | | 0. | | | | | | | | | | | |
| | | | GENERAL FREQUENCY | | | | | | | | | | | | | | | | 0. | |
| TOTALS FOR THIS STATION | | | | | | | 2576. | | | 0. | 20.4 | 5.7 | 0. | 2.9 | 6.2 | 0.1 | 64.7 | 0. | 0. | 0. |

Figure 3 *Network data load detail report.*



DOCUMENT ACTIVITY REPORT

| STATION | FORM | | | TYPE 1 STATIONS - INTRAACTIONS | | | | | | | | TYPE 2 STATIONS - INTERACTIONS | | | | | | | | TYPE 3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | NO | TITLE | F VOL | FROM | | | | TO | | | | FROM | | | | TO | | | | OFF BASE |
| 2000 DATA SERV | | | | | | | | | | | | | | | | | | | | |
| | | | D 1000 | | | | 0 | | | | 0 | | | | 0 | 9999 | | | 0 | 0 |
| | | | D 026M | 2000 | 2000 | | 0 | 2000 | | | 0 | 8400 | | | 0 | | | | D | 0 |
| | | | R | 2000 | 2000 | 2000 | 1 | 2000 | 2000 | 2000 | 1 | 8200 | 8200 | 8500 | 2 | | | | 0 | 0 |
| | LOCC050 | REQUISITION | O | 2000 | 2000 | | 0 | | | | 0 | 8400 | | | 0 | 9300 | | | 0 | 0 |
| | | | W | | | | 0 | | | | 0 | | | | D | 8200 | | | 0 | 0 |
| | | | Q 108M | | | | 0 | | | | 0 | | | | 0 | 8300 | | | D | 0 |
| | LDCC060 | ROUTED ITM CARD | O 1000 | 2000 | 2000 | | 0 | 2000 | 2000 | 2000 | 1 | 8220 | 8210 | | 0 | 8220 | | | 0 | 0 |
| | | | W | | | | 0 | | | | 0 | | | | 0 | 8210 | | | D | 0 |
| | | | Q 015M | | | | 0 | | | | 0 | | | | 0 | 8210 | | | D | 0 |
| | LDCC070 | SCH SKILL DECRSE | D | | | | 0 | | | | 0 | 5000 | | | 0 | 5000 | | | 0 | 0 |
| | LDCC090 | UNASSGN CONT CO | O 0031 | | | | 0 | 2000 | | | 0 | 8110 | | | 0 | | | | 0 | 0 |
| | LOCC080 | STD ADJUSTMT CD | Q 7000 | 2000 | | | 0 | 2000 | | | 0 | 7000 | | | 0 | | | | 0 | 0 |
| | | | Q 011M | 2000 | 2000 | 2000 | 2 | | | | 0 | | | | 0 | 9999 | | | 0 | 0 |
| | | | Q 018M X | 2000 | | | 0 | | | | 0 | | | | 0 | 8100 | 7000 | | 0 | 0 |
| | LOCC090 | UNASSGN CONT CD | O 0081 | | | | 0 | | | | 0 | 8110 | | | 0 | 8110 | | | 0 | 0 |
| | LDC0010 | CONTRDL NO CO | D 0081 | | | | 0 | | | | 0 | | | | 0 | 8110 | | | 0 | 0 |
| | | | W | | | | 0 | | | | 0 | | | | 0 | 8110 | | | 0 | 0 |
| | LOC0020 | CONT NO CROSS RF | D 0081 | | | | 0 | | | | 0 | | | | 0 | 8110 | | | 0 | 0 |
| | | | W | | | | 0 | | | | D | | | | 0 | 8110 | | | 0 | 0 |
| | LDCD050 | STK LIST CHG REF | W 0125 | | | | 0 | | | | 0 | | | | 0 | 8200 | 8100 | 5000 | 1 | 0 |
| | LDCE010 | ACTUAL LABR UTIL | O 0034 | | | | 0 | | | | 0 | | | | 0 | 5000 | 8200 | | 0 | 0 |
| | LOCE020 | MATL COST TRANS | O 0100 | | | | 0 | | | | 0 | | | | 0 | 4020 | | | 0 | 0 |
| | LDCE03D | SKILL ANALYSIS | Q DD29 | | | | 0 | | | | 0 | | | | 0 | 5000 | 8500 | | 0 | 0 |

Figure 4 *Document activity report.*

indicates the function of the location as to origination, control, storage, or relay point in the system. The relationship of various locations in the system provide useful information in deciding potential for integration or centralization. The description of the files at each location may indicate the need for change in storage media or reduction of redundant information.

Network Load Analysis. The data from the document specification and disposition forms are sorted by station identity, form number and card code to develop reports for each activity by identity code, frequency of processing and special time requirements. The network data load detail report shown in figure 3 list all documents, forms and reports processed by an activity (or unit) grouped by identity code, frequency of processing and special requirements. The volume of documents is listed by frequency of processing and converted to a monthly basis to facilitate comparison among activities. From an analysis of the volume associated with each identity code, the analyst can determine the primary function of the activity under consideration. Summary reports may also be prepared showing the total data flow network and the relationship of each activity to the overall network workload.

This form indicates that Station No. 2 processes eleven types of documents, each on a monthly basis and a total volume of forty per month.

Document Activity Analysis. The analyst may use the document activity report shown in figure 4 to follow the document flow

| SEQUENCE NUMBER | EVENT | STATION | DOCUMENT NUMBER | ID | FM | F | SPEC TIME | VOL | PROCESSING O | T | D | S | I | O | ACTION VERB | DOC/ STAT | DISPOSITION HOW | STATION | SEQUENCE NUMBER |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 0. | RECORD CURRENT WKLOS | DATA SERV | FILT080 | IU | MT | E | | 0183 | X | | | | | | PREPAR | FIL 60 | | DATA SERV | 4 1000000. |
| 4 100000. | APLY NEW FAC TO WKLD | DATA SERV | FIL 60 | IF | MT | E | | | X | | | | | | COMPUT | FIL 61 | | DATA SERV | 4 200000. |
| 4 200000. | DET SPAC REQ BY WKLO | DATA SERV | FIL 60 | IF | MT | E | | | X | | | | | | COMPAR | FIL 61 | | DATA SERV | 4 300000. |
| 4 300000. | AFTER APPLY FACTORS | DATA SERV | FIL 60 | IX | MT | E | | | X | | | | | | PREPAR | FILT180 | | DATA SERV | 4 400000. |
| 4 310000. | SUMMARIZ TO DCSN COD | DATA SERV | FILT180 | IF | MT | E | | | X | | | | | | COMPAR | FILT150 | | DATA SERV | 4 320000. |
| 4 320000. | SEMI-ANNUAL PROCESSG | DATA SERV | FILT180 | F | PC | E | | | | | | | | | | | | DATA SERV | 4 330000. |
| 4 330000. | AFTER SUMMARIZATION | DATA SERV | FILT180 | IF | MT | E | | | X | | | | | | UPDATE | FILT180 | | DATA SERV | 4 340000. |
| 4 340000. | PREPARE REPORT | DATA SERV | FILT180 | IX | MT | E | | | X | | | | | | PREPAR | LOCE110 | | AFLC HQS | 4 350000. |
| 4 341000. | DISTRIBUTION | DATA SERV | LUCE110 | O | OP | E | | | | | | | | | | | HNDCY | INDUST ENG | 4 342000. |
| | | | | | | | | | | | | | | | | | TRANS | AFLC HQS | 4 343000. |
| 4 342000. | DETERMIN NEW WKLDS | INDUST ENG | LOCE110 | IF | DP | E | | | X | | | | | | COMPAR | LUCE180 | | INDUST ENG | 4 344000. |
| 4 344000. | DETERMIN CHANGE REQO | INDUST ENG | LOCE110 | IF | DP | E | | | X | | | | | | COMPAR | FIL 55 | | INDUST ENG | 4 345000. |
| 4 345000. | AFTER E180/55 COMPAR | INDUST ENG | LOCE110 | IX | DP | E | | | X | | | | | | PREPAR | LOCA020 | | INDUST ENG | 4 346000. |
| 4 345100. | FORWARD FOR PROCESSG | INDUST ENG | LUCA020 | O | DM | E | | | | | | | | | | | HNDCY | DATA SERV | 4 345200. |
| 4 345200. | KEY PUNCH | DATA SERV | LOCA020 | IF | DM | E | | | X | | | | | | PREPAR | LUCB020 | | DESTROY | 4 345300. |
| 4 345210. | RECORD BUILD MEASURE | DATA SERV | LOCB020 | IO | PC | E | | | X | | | | | | PREPAR | FIL 61 | | DATA SERV | 4 345220. |
| 4 345211. | NEW SPACE/MAN RATES | DATA SERV | FIL 61 | IF | MT | E | | | X | | | | | | COMPUT | FIL 60 | | DATA SERV | 4 345212. |
| 4 345212. | MATCH SPACE/WKLO REQ | DATA SERV | FIL 61 | IF | MT | E | | | X | | | | | | COMPAR | FIL 60 | | DATA SERV | 4 345213. |
| 4 345213. | AFTER COMP SP/MN RAT | DATA SERV | FIL 61 | IX | MT | E | | | X | | | | | | UPDATE | FIL 61 | | DATA SERV | 4 345214. |
| 4 345214. | SEMI-ANNUAL PROCESSG | DATA SERV | FIL 61 | F | PC | E | | | | | | | | | | | | DATA SERV | 4 345215. |
| 4 346000. | AFTER E180/55 COMPAR | INDUST ENG | LUCE110 | IX | DP | E | | | X | | | | | | PREPAR | LUCA030 | | INDUST ENG | 4 347000. |
| 4 346100. | FORWARD FOR PROCESSG | INDUST ENG | LOCA030 | O | DM | E | | | | | | | | | | | HNDCY | DATA SERV | 4 346200. |
| 4 346200. | KEY PUNCH | DATA SERV | LOCA030 | IF | DM | E | | | X | | | | | | PREPAR | LUCB030 | | DESTROY | 4 346300. |
| 4 346210. | RECORD BLD/WKLD IDTY | DATA SERV | LUCB030 | IO | PC | E | | | X | | | | | | UPDATE | FIL 60 | | DATA SERV | 4 346220. |
| 4 347000. | AFTER E180/55 COMPAR | INDUST ENG | LOCE110 | IX | DP | E | | | X | | | | | | PREPAR | LOCA050 | | INDUST ENG | 4 348000. |
| 4 347100. | FORWARD FOR PROCESSG | INDUST ENG | LOCA050 | O | DM | E | | | | | | | | | | | HNDCY | DATA SERV | 4 347200. |
| 4 347200. | KEY PUNCH | DATA SERV | LOCA050 | IF | DM | E | | | X | | | | | | PREPAR | LOCB050 | | DESTROY | 4 347300. |
| 4 347210. | RECORD CURRENT UTILZ | DATA SERV | LOCB050 | IF | PC | E | | | X | | | | | | UPDATE | FIL 61 | | DATA SERV | 4 347220. |
| 4 348000. | AFTER E180/55 COMPAR | INDUST ENG | LUCE110 | IX | DP | E | | | X | | | | | | PREPAR | LOCA060 | | INDUST ENG | 4 349000. |
| 4 348100. | FORWARD FOR PROCESSG | INDUST ENG | LOCA060 | O | DM | E | | | | | | | | | | | HNDCY | DATA SERV | 4 348200. |
| 4 348200. | KEY PUNCH | DATA SERV | LOCA060 | IF | DM | E | | | X | | | | | | PREPAR | LOCB060 | | DESTROY | 4 348300. |
| 4 348210. | RECORD FUTURE UTILZN | DATA SERV | LOCB060 | IF | PC | E | | | X | | | | | | UPDATE | FIL 61 | | DATA SERV | 4 348220. |
| 4 349000. | AFTER E180/55 COMPAR | INDUST ENG | LOCE110 | IX | DP | E | | | X | | | | | | PREPAR | LOCA170 | | INDUST ENG | 4 350000. |
| 4 349100. | FORWARD FOR PROCESSG | INDUST ENG | LOCA170 | O | DM | E | | | | | | | | | | | HNDCY | DATA SERV | 4 349200. |
| 4 349200. | KEY PUNCH | DATA SERV | LOCA170 | IF | DM | E | | | X | | | | | | PREPAR | LOCB170 | | DESTROY | 4 349300. |
| 4 349210. | RECORD SPACE ALLOC | DATA SERV | LUCB170 | IF | PC | E | | | X | | | | | | UPDATE | FIL 61 | | DATA SERV | 4 349220. |
| 4 343000. | REFERENCE + ANALYSIS | AFLC HQS | LOCE110 | IF | DP | E | | | | | | X | | | STORE | FIL 65 | | AFLC HQS | 4 351000. |
| 4 350000. | PREPAR BLDG DRAWINGS | INDUST ENG | LUCE110 | IF | DP | E | | | X | | | | | | COMPAR | LOC 55 | | INDUST ENG | 4 352000. |
| 4 352000. | AFTER LOC55 COMPARE | INDUST ENG | LUCE110 | IX | DP | E | | | X | | | | | | PREPAR | LOC 56 | AMAIL | AFLC HQS | 4 353000. |
| 4 352100. | DISTRIBUTION | INDUST ENG | LOC 56 | O | DM | E | | | | | | | | | | | AMAIL | AFLC HQS | 4 352200. |
| 4 352200. | REFERENCE + ANALYSIS | AFLC HQS | LOC 56 | IF | DM | E | | | | | | X | | | STORE | FIL 64 | | AFLC HQS | 4 352300. |
| 4 350000. | PREPAR COMMAND REQTS | AFLC HQS | FILT180 | IF | MT | E | | | X | | | | | | PREPAR | FIL 63 | | AFLC HQS | 4 360000. |
| 4 351000. | SEMI-ANNUAL PROCESSG | AFLC HQS | FIL 63 | F | PC | E | | | | | | | | | | | | AFLC HQS | 4 352000. |
| 4 400000. | SEMI ANNUAL PROCESSG | DATA SERV | FIL 60 | F | PC | E | | | | | | | | | | | | DATA SERV | 4 500000. |

END OF THIS CHAIN

Figure 5 *Event-type flow list.*

between different data processing areas, functional areas and activities. It identifies documents processed at a particular activity and separate listing can be prepared for documents created and used by the same unit. The degree of potential integration within and between functional activities can be established from this report. Independent activities will be highlighted because they have little or no transfer of documents to or from other activities. Closely interrelated data-processing activities in several units indicate a strong case for centralized processing, and vice versa.

The document activity report illustrated indicates that form no. LOCC050, a requisition has interactions within the Data Services station (2200) and also with stations no. 8400 & 9300.

Flow Listing Analysis. This analysis uses the event-oriented approach and emphasizes the fact that an event creates a document or action at a particular activity and focuses the analysis on the chain of related events as illustrated in the event-type flow list, figure 5. It shows a particular event and its sequence in the related chain of events by activity and document identified with it. The processing actions taken as a result of receiving a document at a particular activity are identified on the flow list as affecting the document alone or as also initiating some other operations. It will also identify incomplete event chains.

The Flow Analysis listing provides a chronological list of events. As an example the Data Services section conduct events

numbers 4-0 to 4-341000 using document numbers FILT080, FIL60, FILT180 and LOCE110 on which they prepare document FIL60, COMPUTE DOCUMENT FIL61, prepare document FIL180 and compare this with document FIL150. The final disposition of this series of events is to the industrial Engineering Division.

Comments and recommendations are made from these analyses that will advise on adequacy of the present capability and recommend possible improvements to the present system. These improvements will be of two types: (1) Improvements that would not require the use of an automated system and (2) Improvements that would require the use of an automated system.

The design study will include complete organization and information flow charts of both the present system and the proposed system if required. See Appendix A for recommended format of the report.

## C. DESIGN REVIEW AND APPROVAL

The design study report will be presented to the user top management for review and approval. The systems analysis group together with the user personnel assigned to assist in the design study should be available to clarify any phase of the report not understood. This approval will signify that the user and the analysts understand the requirement and agree with the proposed developmental approach. It should be stressed here that this approval does not bind or fix the design irrevocably. It is

TIME PHASING

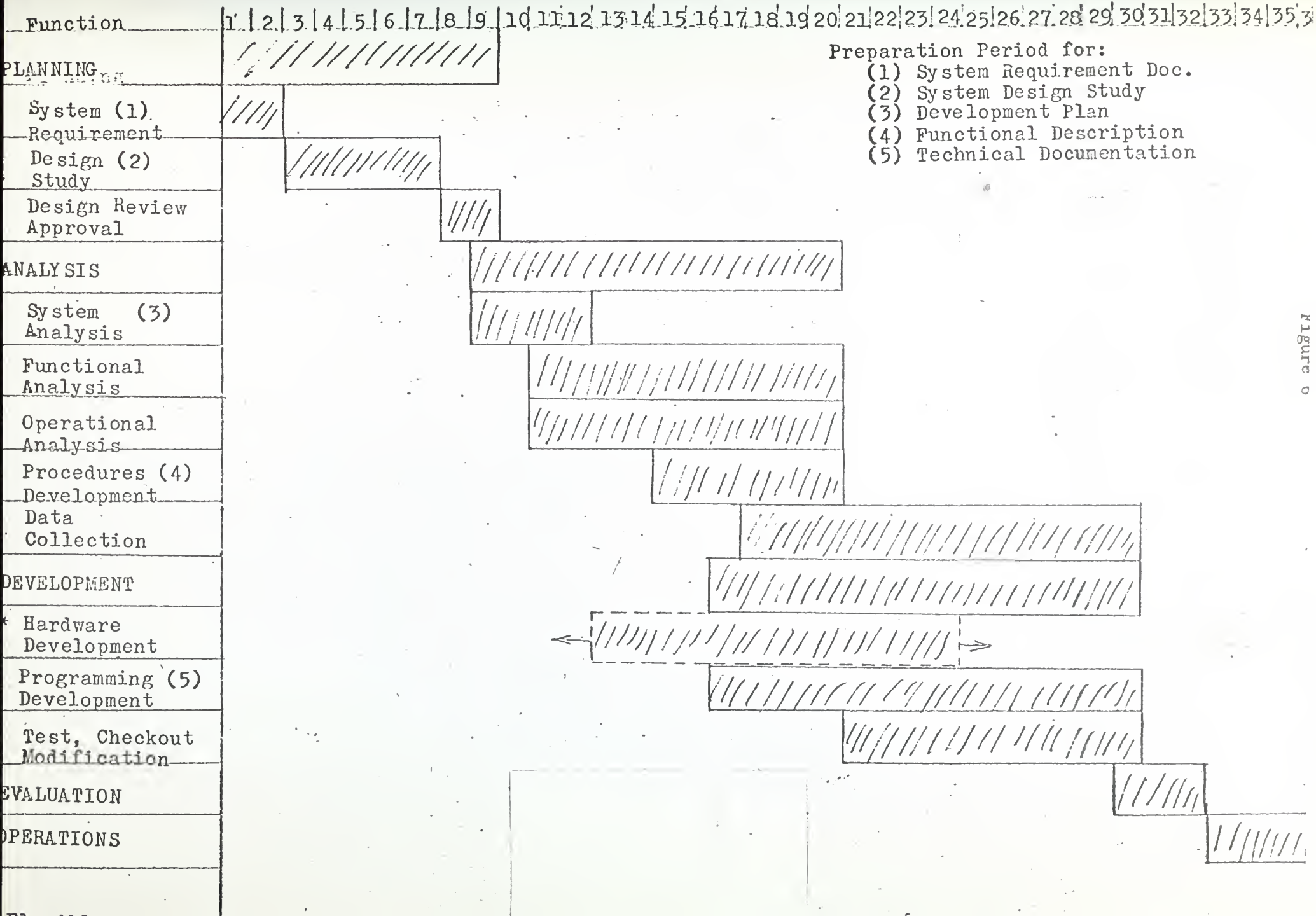



Figure 6

obvious that if the system is complex and dynamic there will be changes required. These design changes may be major or minor since the design study will not generally do as detailed an analysis as is required by the complete operational and functional design.

PROJECT DEVELOPMENT PLAN

DATE _____

| PHASE | STARTING DATE | COMPLETE-TION DATE | MAN MONTHS ALLOC. | QUANTITY REQUIRED | UNIT OF MEASURE |
|---|---|---|---|---|---|
| ANALYSIS | | | | | NA |
| CODING | | | | | NO. OF INSTRUCTIONS |
| CHECKOUT | | | | | COMPUTER TIME IN HOURS |
| DATA COLLEC-TION AND CONVERSION | | | | | |
| TURNOVER | | | | NA | NA |

COMMENTS:

_____
SYSTEM ANALYSTS

Figure 7

# CHAPTER III

# ANALYSIS

The analysis phase of development is the connecting link between the design and programming of an automated system. It is much more detailed in that it provides analysis of the problem from a functional point of view, that is, it describes the system being developed by the functions or tasks that are being automated and describes how these functions and tasks will be automated.

## DETAILED SYSTEMS ANALYSIS

With the approval of the design study, the more extensive systems analysis may be initiated. This is accomplished in two phases, i.e.: the functional analysis and the operational analysis.

The first step in conducting these analyses is the preparation of a "Plan of Attack" or development plan. This development plan will give estimates of time and effort required to develop the system. These estimates will be the best judgement of the analysts and programmers of the scope and range of the system and will be prepared by phases. They will contain man-day (month, year) effort required to accomplish the phase. Time tables and "milestone" dates by which the progress of the development may be measured will be included. It should be emphasized here, that this is only an estimate of the effort required based on the best information available to the analysts. The phases will be divided into the

analysis phase, the coding (Programming) phase, the testing phase, the data collection/conversion phase, training and turnover phase. Figure 6 provides a sample of time phasing that illustrates the sequence of events and actions.

The analysis phase progress can only be measured by the expected number of manhours to complete the phase, the coding phase progress can be measured by the nuber of coding instructions completed in a certain time period. The present "State of the Art" provides very little data on what is an average number of coding instructions or steps that should be completed in a specified period. Some programming organizations use ten "debugged" programming steps per day as a standard. This is a very uncertain measurement since a great deal depends on the complexity of the program and the interactions necessary with other systems. In the test and checkout phase the measurement of progress (and again an unsure one) is the number of hours of computer time required to make the system operable. Some of the possible criteria for measuring efficiency and progress in the coding and system checkout phases may be:

1. Minimum programming effort i.e; the simplest method for coding to provide minimal coding and debugging time.

2. Program execution time minimum i.e; minimal computer running time.

3. Insure that the program occupy as little computer memory as possible.

4. Provide a program that is flexible, i.e; insure the program is relatively easy to modify or change.

Each of these criteria or constants will require the analyst to consider alternative methods of system development. Figure 7 contains a recommended format for a development plan.

1. Functional Analysis

A comprehensive scientific investigation to define the problems and the most feasible method of solution from a functional stand point is now conducted, taking into consideration both effectiveness and cost. It will include a more detailed review and analysis of the user requirements and of the information flow than was completed for the design study. The design study will be the starting point for this analysis.

With this design study the analyst must describe the scope and function of the system. Using the information flow analysis completed in the design study, a comparison of the document communications process is made with the formal organizational communications process that will enable him to discover duplication, redundancies and inadequacies that were not readily apparent during the design study. This will allow him to design the new system alleviating many of these problems. This may appear to be redundant effort in view of the design study effort, however, it is advisable, at this later point in the development, to review the flow analysis to determine if any changes in concept corrects deficiencies dis-

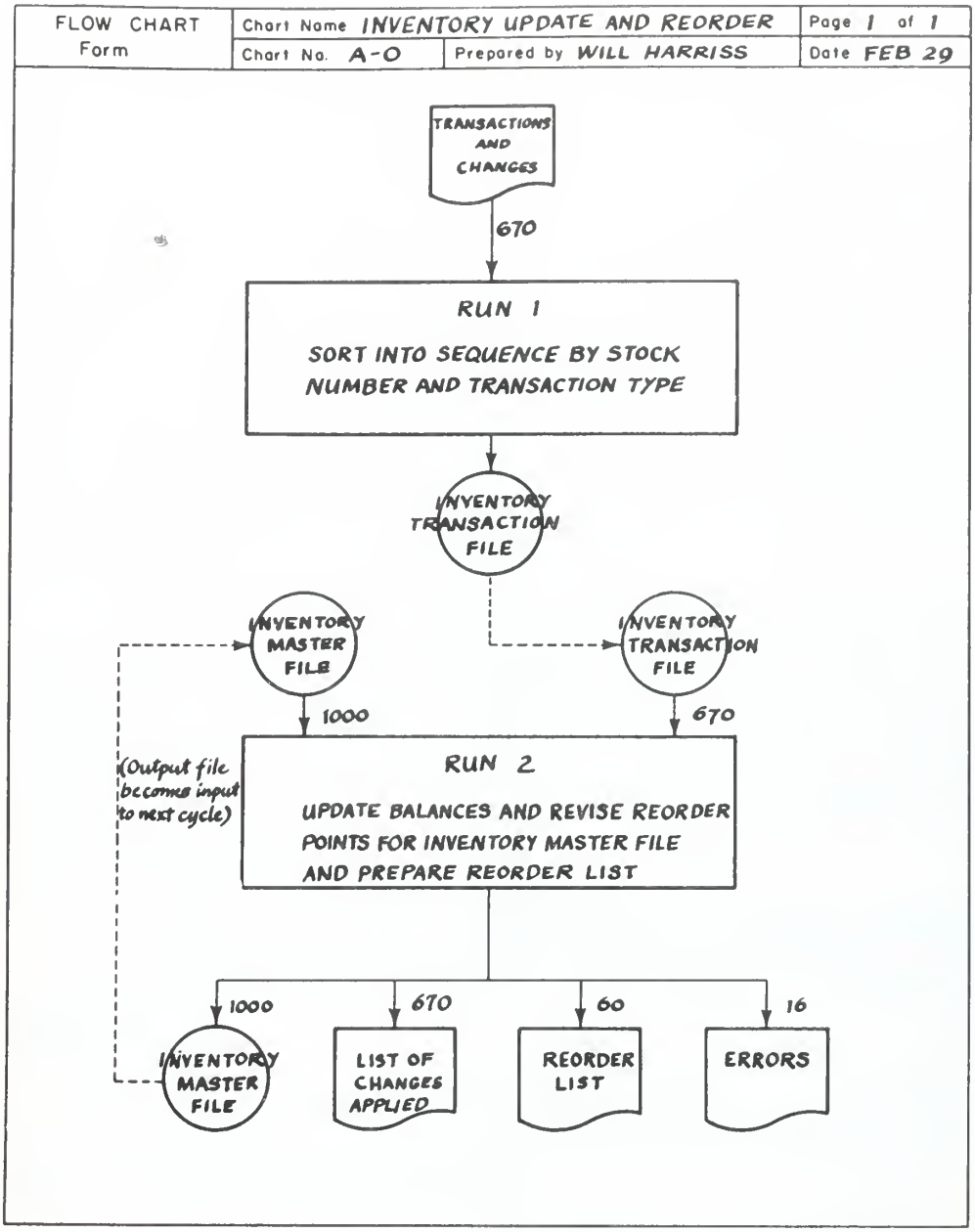



Figure 8 *Run diagram for inventory updating and reorder procedure.*

covered. There are several methods available to perform these tasks. One method may be the use of "automated analysis."[3] The Rand Corporation had developed a system called "Autosate" (Automatic Data System Analysis Technique). Autosate is an electronic processor for organizing and analyzing the facts collected about the flow of data in the system. It provides simplified and standardized input collection so the data collection may be accomplished by a non analyst. It performs most of the routine tasks of checking, tracing, reconciling, verfiying and flow charting of data so that the analyst may conduct the more rigorous higher level analysis and creative design work.

The International Business Machines Corporation has also developed a systems analysis program in connection with their Documentation Aids System.[4] This particular analysis program is limited in that it can be used only to analyze an automated system. It is designed to:

1. Improve and update documentation of existing programs.

2. Ease maintenance problems by providing up to date program documentation.

3. Eliminate certain clerical and routine functions associated with documentation and conversion.

[3]Gregory, R. H. and R. L. Van Horn, Automatic Data Processing Systems - Principles and Procedures, 1964: 190.

[4]IBM Reference C20-1612, Kingston, New York (1964)

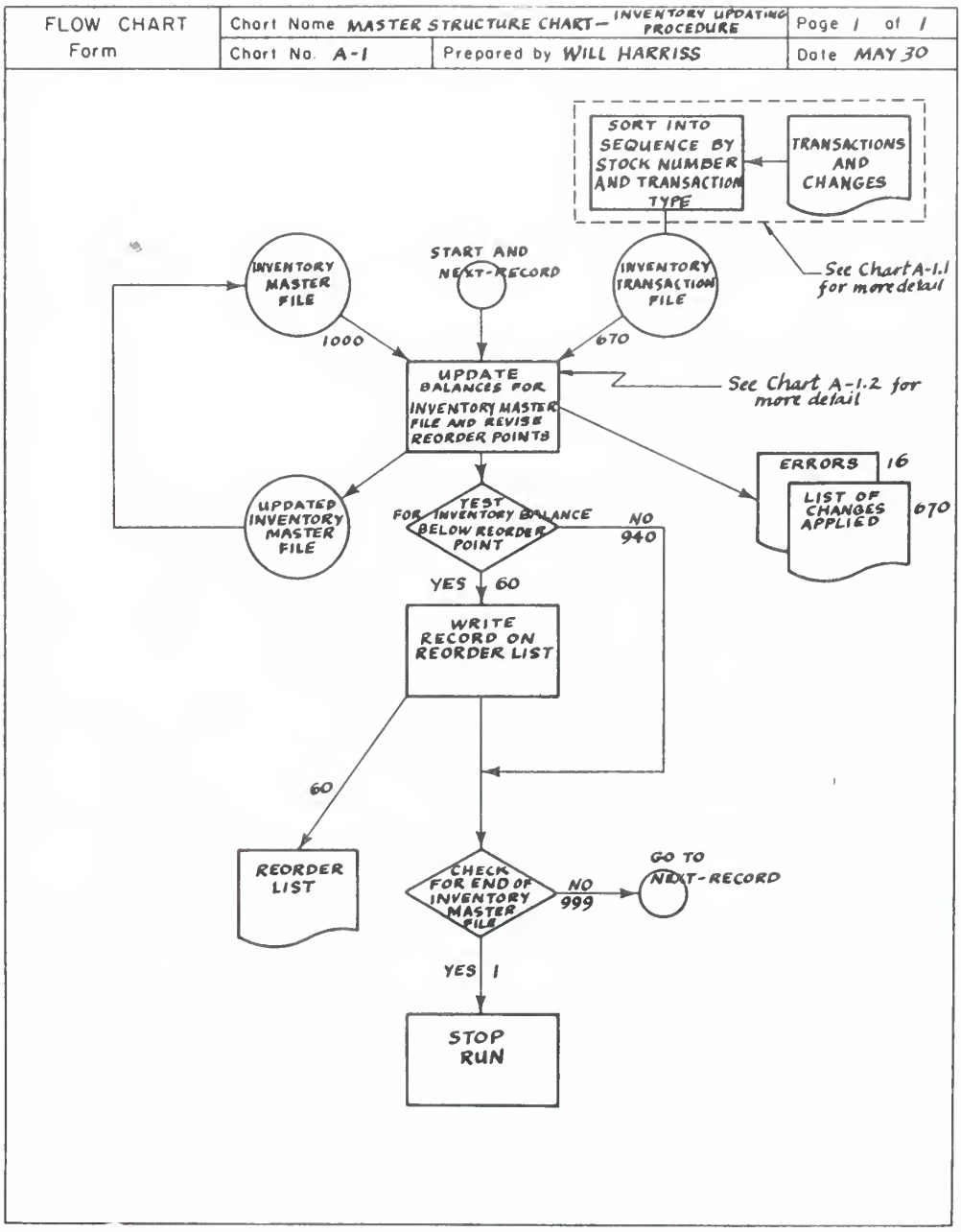



**Figure** *Flow chart of structure for inventory updating and reorder procedure.*

4. Improve programming efficiency by the standardization of documentation techniques.

5. Encourage the user to reprogram in a higher-level language as an example, Fortran, Algol and Cobol.[5]

This makes it ideal for redesign or updating of an automated system but provides little assistance in development of a previously nonautomated one.

Other methods of analyses are those of Simulation, run diagramming, structural flow charting, or use of decision tables.

Simulation is a well known technique which flows through, step by step, the events that are expected to occur in a proposed system using prior experience, logical forecasting and probability theory to estimate the timing, number and type of occurrences that will result from various combinations of input data. This is a far less expensive process than actual operational development.

Run diagramming presents a general overall view of the major functions of a system. It shows fundamentally in short English language statements how the various files, data and processes interact in the system. It is a very much simplified version of the programming flow charts which provide much higher level of detail. Figure 8 gives an example of a run diagram that shows the procedure for updating an inventory file and the method for reordering on a periodic basis. Each rectangular box represents a

[5]Ibid

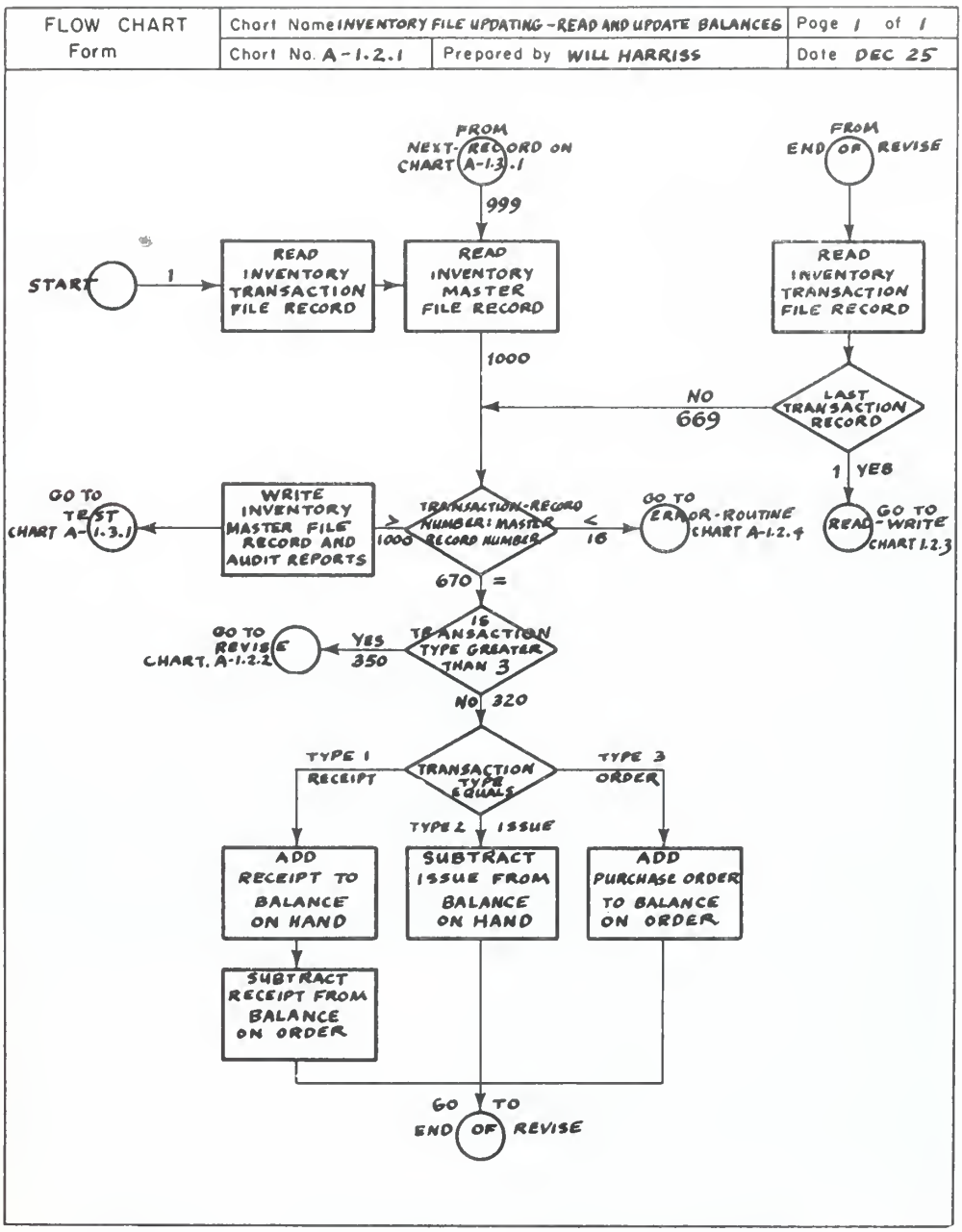



**Figure 10** *Procedure for file reading and balance updating.*

| DECISION TABLE Form | Table Name INVENTORY FILE UPDATE | | | Page 1 of 1 |
|---|---|---|---|---|
| | Chart No. T-1.2.1 | Prepared by WILL HARRISS | | Date FEB 29 |

| Stub | Body | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Rule Number | | | | | | | | | | | | | | |
| Conditions | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| START | Y | N | N | N | N | N | N | N | N | | | | | | |
| LAST TRANSACTION RECORD | – | N | N | N | N | N | N | N | Y | | | | | | |
| TRANSACTION NO: MASTER RECORD NO | – | > | = | = | = | = | = | < | – | | | | | | |
| TRANSACTION TYPE EQUALS | – | – | 1 | 2 | 3 | 4 | 5 | – | – | | | | | | |
| | | | | | | | | | | | | | | | |
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| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| Actions | | | | | | | | | | | | | | | |
| ADD RECEIPT TO BALANCE ON HAND | | | X | | | | | | | | | | | | |
| SUBTRACT RECEIPT FROM BALANCE ON ORDER | | | X | | | | | | | | | | | | |
| SUBTRACT ISSUE FROM BALANCE ON HAND | | | | X | | | | | | | | | | | |
| ADD PURCHASE ORDER TO BALANCE ON ORDER | | | | | X | | | | | | | | | | |
| GO TO ERROR-ROUTINE TABLE | | | | | | | | X | | | | | | | |
| PERFORM REVISE TABLE | | | | | | X | X | | | | | | | | |
| READ INVENTORY TRANSACTION FILE RECORD | X | | X | X | X | X | X | | | | | | | | |
| WRITE INVENTORY MASTER FILE RECORD | | X | | | | | | | | | | | | | |
| PERFORM TEST TABLE | | X | | | | | | | | | | | | | |
| READ INVENTORY MASTER FILE RECORD | X | X | | | | | | | | | | | | | |
| GO TO INVENTORY FILE UPDATE TABLE | X | X | X | X | X | X | X | | | | | | | | |
| GO TO READ-WRITE TABLE | | | | | | | | | X | | | | | | |
| | | | | | | | | | | | | | | | |
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**Figure 11** *Decision table for inventory file updating.*

run, i.e; the processing of one set of inputs. The arrows show whether a file or document is an input to or output from a run and the numbers indicate the volume. In Run 1, the data in the inventory transaction file are sorted into sequence by stock number and transaction type. In Run 2, both the sorted inventory transaction file and the inventory master file are inputs to processing. The outputs from processing are the updated master file of a use in the next cycle, lists of changes applied, a reorder list, and errors. Error may consist of transaction records without corresponding master file records, records out of sequence and negative balances.

The structural flow charts mentioned above are prepared during the overall design of an automated system. They describe the time, quantities and type of inputs, processing, output and files. They may be differentiated from programming flow charts in that they give a general description of the process in more detail than the Run diagram but stop short of presenting program instruction sequences. A sample structural flow chart is shown in figure 9. It illustrates a method for updating an inventory master file. Identification names (numbers) are given to the major blocks, documents and files. This name or number should be used on all flow charts to identify the same items. This flow chart shows the volume of activity, i.e; the number of records or the times each path is used. As an example the inventory master file contains 1000 records and the number of items below the reorder point is sixty (60) as indicated on the "yes" branch from the test for

inventory balance. These figures are useful for calculating work load and processing times.

Decision tables offer a more versatile display of diagramming various sequences of action than does the structural flow chart. It allows the illustration of several alternate sequences of action through which one can clearly observe the obvious path through the program. In flow charting it is difficult to obtain such a path since one must often consider all the prior conditions made that may influence the path of the process. The use of decision tables solves this problem, in that all prior conditions are readily displayed. Figures 10 and 11 provide a comparison of a flow chart and a decision table for an Inventory file updating procedure.

The flow chart indicates several decision diamonds in series to describe the inventory file updating. It is necessary to refer to several flow charts in order to follow the complete inventory file process. This procedure becomes very complex. As an example, if the transaction type is greater than 3 it is necessary to refer to chart A-1.2.2. If it is less than 3 a three decision diamond is necessary. The numerals indicate the number of expected actions. With the decision table this confusion is not apparent.

The decision table is set up with three sections, the conditions, the rules and the actions. The conditions correspond to the contents of the decision diamond of the flow chart, but providing more branches or alternatives for action. The actions represent the processing blocks of the flow chart presented in the

sequence of execution desired. As an example, the sequence of execution for a transaction record for which there is a master record and for which the type of transaction (purchase-Rule five) would be:

1. Match transaction record number with master record number.

2. Match transaction type with rule number.

3. Perform actions indicated by rule number. (In this case transaction type three indicates rule number five)

4. Perform actions:

    a. Add purchase order to balance on order.

    b. Read inventory transaction file record.

    c. Go to inventory file update table. (i.e. - Return to beginning of this table and read next transaction record.)

Two advantages of the decision table is that the condition and action are independent and all conditions are tested for the applicable rule before any action is executed.

These methods of analysis may be done singularly or jointly to perform the analyses suitable for the situation or problem being studies.

2. Operational Analysis

This phase of the analysis will be done in conjunction with the functional analysis phase and will investigate and determine the best operational procedures to be used in developing the system. It may use various "operations analysis" techniques such as Queuing theory,

Linear and Dynamic programming methods and Monte Carlo methods. Caution must be exercised here to insure that the solution fits the problem. Often analysts become too involved in an extremely sophisticated solution to a problem that does not require this sophistication. If the solution is too complex to understand it will not be used. The analyst must always keep in mind the problem to be solved and solve it in the most effective, efficient and least complicated method possible. "Don't solve the wrong problem."

The techniques of Operations Analysis are widely known and used within the data processing environment. An example of the use of Queuing theory and Monte Carlo methods in automated development could be the simulation of data elements entering the system for use in a subroutine. These elements may have an arrival rate that may approximate a certain distribution function. The subroutine may process these elements at a certain service rate which would approximate an exponential distribution. Using various assumed probabilities and Queuing theory, fairly accurate predictions can be made for processing times under most conditions. This is sufficient to indicate that competent systems analysts must be familiar with these methods and able to make sound judgments as to when and how to employ them in obtaining solutions to the "problem."

3. Procedures Development

During the analysis phase the procedures development plan will be made. This will be in the form of a formal functional descript-

ion of the system in a prescribed format. This may be described as a "documented analysis of the area under consideration for automation"[6] including all conclusions and general specifications for the proposed system. It must be written so that the user (possibly non ADP orientated) will have a clear understanding of the impact of the proposed system modification and encourage user participation in the project development. Below is a summary of the contents of this document. Appendix B is a complete outline of the format.

In providing a clear statement of operational capability the functional description will:

1. Provide a basis for defining the work to be accomplished and the program to be developed.

2. Provide in writing a basis for mutual understanding of requirements between the user and the system analyst.

3. Assist in obtaining concurrence between the user and the developer. (System Analyst)

4. Provide the user with information requirements necessary for data collection and preparation.

To accomplish this, the functional description will outline existing procedures, including personnel responsibilities, present equipment, files, system cycling frequency, time delays and a block diagram description of information transmitted from data receipt through processing and use. Utilizing the techniques of

[6]Naval Command Systems Support Activity Instruction 5230.1A 17 July 1964.

information flow analysis in conjunction with the methods of simulation, run diagramming, flow charting and decision tables described above, the documentation will outline the development of the proposed system and present a comparison of the two systems. Alternate recommendations will be described with consideration given to the costs and requirements of the desired system. Details will be provided in man-power requirements, machine time, equipment requirements and processing times for development and operation of the system. These details must include present functions or operations that are being deleted and functional descriptions of new operating procedures including a capability or grade level of personnel required.

A summary of the impact on the user command as a result of the installation of the new system will be provided.

A detailed description of the following elements will be provided:

1. Equipment required.

2. System programs and subprograms to be used.

3. Data requirements including files, formats, frequency and sources.

4. Data transformation - a description of the techniques and processes for converting input data into required formats.

5. Output - report and display formats will be described including user, content of report or display, purpose and frequency.

6. Query capability - a description of the query procedure

including types, limitations and flexibility.

7. System capacity - specifications for data volume, accuracy and response time available.

8. Manpower requirements - A summary of the requirements to:

   a. Establish the data base for the system.

   b. Maintain data base.

   c. Operate and maintain the program.

The completion of this report, its review and acceptance of the concept of development and operation by the user completes the analysis phases and provides a firm decision on the concept of the system development. The developer now has a solid base for project completion and the user has a clear, firm description of what will be provided as an automated system. Hereafter, there can be no change in concept or major modification of method of development without a complete reappraisal of the entire project.

4. Data Collection

Data collection will be the main responsibility of the user. The format design necessary will be prepared by the system analysis group, and will include detailed instructions for preparation. The raw data to be received will be outlined and data card columns, number of data cards required and frequency of preparation will be determined.

Using as aids, the data collection format, flow charts and decision tables prepared in the design and analysis phases, the

various standardized inputs formats are designed. Here the ingenuity of the systems analyst is taxed. He must design the input formats that are readily understandable by the user, that is, avoiding the requirement for complex conversion of the raw data into the technical computer language by the user. Yet, they must contain complete information properly sequenced so as to permit relative ease of conversion to the computer language and key punching format by the analyst. There must also be the attempt to combine logically related data in a single format, but avoid design of extremely complex or unwieldy documents. The effectiveness of the program will be no better than the validity of the data entered, therefore, it is obvious that this phase is critical to the successful operation of the system.

# CHAPTER IV

# DEVELOPMENT

With a firm concept and system design in hand, the analysts, system programmers, and programmers may commence actual program development. This will consist of preparing detail program flow charts, program coding and checkout. This development is accomplished in two distinct areas, hardware development and programming development.

## A. HARDWARE DEVELOPMENT

If required, hardware development may be conducted concurrently with the analysis. Care must be exercised that selection of equipment be accomplished without preconceived ideas on type of equipment. Equipment must fit the system. The system should not be designed around equipment.

In certain areas, however, such as command and control, very large capacity equipments are in use and development of subsystems within the command and control area must have the equipment configuration as a preset parameter.

Hardware development is a large and very complex study. Hardware manufacturers are continuously conducting research to design and produce new equipment for faster more accurate processing method. Apparently the main problem in system development is being able to define the requirements well enough to choose the

proper equipment.

## B. PROGRAMMING DEVELOPMENT

The term programming may be considered in two ways: that of problem analysis and that of writing the program instructions. In this paper it refers to writing the program instructions. The functional description is translated into detailed flow charts and a series of subprograms and subroutines. Flow charts mentioned here are programming flow charts. Programming flow charts describe the specific operations and decisions that are performed in a stored memory program.

The flow chart symbols shown in Figure 1 are used for the programming flow charts as well as the structural flow charts. Various decisions must be made prior to actual coding of the system. The analyst must decide on the language in which the system will be written. Here, he has a wide variety of choices. However, he must consider several parameters. These may be: the type of problem - scientific, business or mathematical; the frequency with which the problem must be solved - real time or delayed processing application; the type of input - direct from source documents or via some intermediate compiling device. If the problem is scientific a programming language such as FORTRAN or JOVIAL may be required. For a business application COBOL may be used. These are only a few of the criteria that may be considered. Many more could be necessary depending on the type

and complexity of the problem. Up to this point in the analysis no mention has been made as to the hardware configuration. It was pointed out in Chapter IV, Section A, that the analysis to this point need not consider the hardware configuration. The analyst must now give this consideration. Size and speed of the computer may be a limitation. The input media may dictate certain programming methods. An example would be the methods used in programming for sequencial processing versus those used for random access processing.

Sequential processing uses data records that are in a series storage such as magnetic tape which would require methods of sorting and editing that scan the complete file in order to extract or correct a single record. Records must be sequenced in the most efficient manner so that information required most often is near the beginning of the tape.

Random access processing will not have this limitation in that each record or bit of information can be obtained independent of other information.

Another consideration will be the availability of compilers or assemblers. This will dictate the use of either a problem - oriented language (machine independent) or machine - oriented language (machine dependent). The use of a machine - oriented language requires little or no translation into computers numeric order code. The mnemonic (alpha) codes would require translation on a one for one basis. The use of a problem - oriented language,

such as Fortran, Cobol, Algol or Jovial, however, requires the use of much more elaborate translators and compilers to convert each program instruction into one or several machine instructions. It is obvious that if these translators and compilers are not available, then these also must be developed. This will add to the programming complexity. The trade offs of simplicity and efficiency of the machine - oriented language against the sophistication and versatility of the problem - oriented language must be considered in the light of the problem to be solved.

Generally the development of an automated system to perform some set of objectives will not stand alone. Automating an inventory control function will usually be done in conjunction with the automation of the procurement, disposal, accounting and financial control functions to create a complete system. Also other unrelated functions may be developed for the same organization or activity. In order to design and develop a complete, integrated system it is necessary to create, where ever possible, standardized routines and procedures. These routines usually perform the executive function of an integrated system. The basic system monitor is designed to perform "housekeeping" functions such as; execution control which consists of standardized routines for loading and sequencing programs, input-output control, inter-computer communications control and time sharing program control. The availability of these routines in an integrated system eliminates the necessity for detail programming to control these

operations. It does, however, demand the adherence to standardized programming rules. This standardization generally simplifies the programmers task but may have the disadvantage of less efficient operation of the individual program. This decrease in efficiency is usually acceptable since the use of standard routines will increase the overall efficiency of the integrated system. With the various "tools" mentioned above, the programmer is able to translate from the detailed program flow charts and decision tables to the programming code. When writing the source program, the programmer must define each data file and table to be used by the type of file-card, tape or disk; type of processing - random or sequential and the method used for spacing and over flow.

He must specify the input - output requirements including the Macro-Instruction controls for insertion and retrieval at the proper point in the program. Utility routines, such as card to tape, tape to print, disk to tape, etc., must be properly called and sequenced to provide a smooth integration of the computational and input-output operation of the program.

Consideration must be given to querying methodology including types, limitations, flexibility, report formats and output displays.

The programming development will provide extensive documentation on all programs. This documentation is the heart of the operational process of the system. It will contain a user or staff (nonADP) section which will provide a system description giving the capabilities and limitations oriented toward users having no

technical background in ADP. It will contain the description of system inputs including the source, the type (forms, data cards, punched tape, etc.) the volume and frequency. It will also contain the system output, describing in detail the type, (report forms, data card, magnetic tape, visual displays, etc.) format and frequency.

The "technical operations" section will be written in more technical language for use by the maintenance programmer and ADP operations personnel. It will contain detailed flow charts, the symbolic and machine listings of each program or subprogram.

Detailed methods of query preparation for gaining access to information other than from scheduled reports procedures will be provided.

The "system operation" section will describe the computer set up and operation providing detailed online input/output processes such as: printer, card-reader, type units, display equipment, etc.. It will also provide details on data arrangement, tape mounting, sense switch setting, running time, output disposition, error check, EAM procedures, control procedures, etc.. Appendix C gives a complete outline of the final documentation.

## C. TESTING AND CHECKOUT

During programming development the various subprograms, utility programs and subroutines must be tested to insure accurate, properly operating systems. This is usually referred to as

"debugging." It will involve checkout on the computer for which the system is designed. All subroutines must be tested separately and in conjunction with others to insure compatability of the system. During this period corrections and modifications continue in order to develop the most efficient and dynamic system possible. Here it is necessary to stress the accuracy and completeness of the changes to the program documentation. This is vital for future maintenance and modification to the system.

## D. MODIFICATION

Unless an automated system is extremely limited in scope, it must be dynamic and contain the capability to be modified and changed. In order to perform these changes and modifications, at some future time when those originating may not be available, the original program documentation must be complete and clear. Procedures must be instituted that will insure that programming instructions (additions and deletions) are fully documented when they are accomplished. A complete history of program development and modification should be available. This can only be accomplished by management establishing and enforcing rigid policies concerning documentation standards and procedures. This is not to be done to preclude making changes but to insure a complete record of those made.

There have been several methods developed that will automatically prepare a record of any modification made to the program.

Section III-B mentions two of these, Autosate and Documentations Aids System. As mentioned previously the D.A. System is very useful as a maintenance tool for automated systems. Here it would be ideal for modification.

This system consists of four programs and processes source programs written in Symbolic Programming System (SPS), Autocoder, Macro Assembly Program (MAP), Fortran Assembly Program (FAP) or Symbolic Flowchart Language (SFL) for various IBM machine systems.[7] It produces the following program documentation:

1. A storage map of object decks.
2. An analysis listing of source decks.
3. A flowchart of source decks.

These programs are the update program, the analysis program, the flow chart program, and the verification program.

The update program is used to insert, delete or replace programming instructions in the source program. It performs these functions by a file maintenance routine. It is also used to update the symbolic flow chart language, conduct sequence checking and prepare an input tape for the analysis and flow charting programs.

As it implies, the analysis program provides a detailed analysis of each program instruction giving a listing denoting the type of instruction (relative addressing, indexing, indirect addressing or data defining), a cross reference dictionary of symbols used and a statistical analysis of the operations codes,

[7]IBM Document no. H20-0133-0 (1964) p. 1.

i.e. - the frequency of occurrence of each code.

The flow charting program generates an updated flow chart presenting the logic of the source program and uses the output of the analysis program to produce the "symbolic flow chart language."

The verification program is designed to assist the programmer in comparing the source program with the current object program by producing a storage map which presents the contents of core storage after the object program is loaded. It provides location sequences and identifies all program patches made to the object program.

The use of these four programs should substantially ease the workload of the maintenance programmer. It is again pointed out that this simplification can only be accomplished if the original documentation is reliable.

With the completion of the development phase the automated system is available for evaluation and use by the user activity. In order to consolidate the documentation described in this paper Appendix D is provided as a summary of all documentation needed to maintain and modify the system when required.

# CHAPTER V

## EVALUATION AND OPERATION

With the completion of the testing and checkout phase, the system is theoretically ready for operational evaluation. This should be done under actual operating or simulated operating conditions for a specified period of time. These evaluations tests must be conducted by operations personnel under the supervision of the systems analysis group and observed by the users. This will give all concerned the opportunity to evaluate and become familiar with the system. It will also provide a vehicle for communication of criticism or suggestion for more efficient operation. Cost of effectiveness studies may now be conducted to determine the increase of functional efficiency gained by the installation of the automated system. The final acceptance of the complete system is formally prepared releasing the developer from further responsibility. The continued maintenance and modification of the system will now be the responsibility of the user activity.

# CHAPTER VI

## CONCLUSIONS AND ACKNOWLEDGEMENTS

While the technological developments in the field of automation have advanced by great strides in the past twenty years, the administrative progress has moved very slowly. The great speed and versatility of present day computers are being hindered by the lack of proper administrative control.

The day of program development by the "seat of the pants" programmer has past. Automated systems have become so complex and the problems that are being solved are so complicated that systems development requires sophisticated procedures that can only be followed by proper and adequate recording as development progresses.

An automated system without complete documentation will fall into disuse because the reprogramming effort required may be as great as for the original development.

If adequate documentation is provided, including a complete system description, flow charts, block diagrams and anotated listings of all systems and subroutines as is contained in section VII, the modifications and/or changes may only require the efforts of relatively few experienced analysts and programmers.

The key to successful cost effective automated systems is, therefore, complete, clear and timely documents produced during the development.

This paper outlines an approach to the solution to the problem of inadequate or improper documentation in the development of an automated system. It is written in an effort to promote an interest in this problem. There may be other approaches that are being used in the field of automation. There have been many articles written on document and data element standards as evidenced by scanning the recent American Computing Machinery index to the computing reviews.[8] However, the author has been unable to find any specific references to the standardization of analysis and programming procedures and documentation other than those mentioned in this paper.

As it was pointed out, the government has taken an interest by advocating more stress be placed on standardization of computer and system development techniques. There is a great deal yet to be accomplished. The Data Processing System Manager has the responsibility to produce an efficient operating system. In order to do this he must have all the tools to perform the task. With a system properly analyzed, developed and documented he will be able to maintain efficient operation procedures.

In conclusion I would like to acknowledge the advice and constructive criticism provided in writing this paper by Professor James B. Cowie. It has helped develop the area of interest and concern to me.

[8] Association for Computing Machinery, Computing Reviews 1960-1963.

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## APPENDIX A

## REPORT OF DESIGN STUDY

I. Title Page

II. Abstract

A clear and concise statement of the content of the document.

III. Table of Contents

IV. Introduction

A. Background

1. Requirement - An analysis of the requirement contained in the project request presenting clear definitions as to statements contained therein.

2. Staff Responsibilities - A definition and explanation of the present staff responsibilities and the desired capabilities to be provided by the completion of the subject project.

V. Analysis

A. Environment

1. Organizational Relationships - A reference may be made here to information flow and the various interactions of the staff with other users.

2. Problem Areas - A definition of problem areas encountered.

B. Present Methods and Procedures - A discusion of the present staff methods and procedures in performing the functions outlined in the subject project request.

C. System Analysis - an analysis of the present system and proposed system development.

VI. Comments and Recommendations

A. Present Capabilities - A statement and analysis of the adequacy of the present capabilities.

B. Proposed System Requirements

1. Non-ADP - Recommendations as to improvements of present capabilities which would not require the use of ADP systems.

2. ADP - Recommendations as to proposed improvements of present capabilities which would require the use of ADP systems.

APPENDIX 1

Flow charts of the present system.

APPENDIX 2

Flow charts of the proposed system.

APPENDIX 3

Reports on location characteristics and relationships.

Reports on Network load analysis.

Reports on Documentation Activity Analysis.

Reports on File Analysis.

VII. Glossary

VIII. Bibliography

IX. Distribution.

## APPENDIX B

## PRELIMINARY FUNCTIONAL DESCRIPTION FORMAT

A. Introduction

The requirement. A statement of the established requirement with appropriate references.

B. Existing Methods and Procedures

1. A description of existing methods and procedures, including personnel responsibilities, equipments, volumes, frequencies, time delays and a block diagram description of information transmitted from the beginning of data acquisition through its processing and eventual use.

2. Throughout this over-all analysis of the user's present system, quantitative as well as qualitative values which support justification for the need of improvement must be developed.

C. Proposed Methods and Procedures

1. A definitive description of the capability upon which project design will be based. Emphasis should be placed on differences from the existing system. A block diagram of the proposed system will present an over-all view of the planned capability.

2. The description of the proposed methods and procedures must be developed in sufficient depth to demonstrate the impact on man-power, machine time, equipment requirements, processing times and throughput. Where appropriate, alternative methods and

procedures will be described with subsequent discussion of the rationale for the final selection.

D. Environment and Impact

1. A summary of the impact on the user command by the installation of the proposed system. This discussion should include those elements noted in paragraph C as well as the modifications to responsibilities which may result.

2. A detailed description of the following elements is required.

a. Equipment needed to support the proposed system

b. System programs to be employed

c. Data to support the system - volumes, formats, adequacy, frequency, sources.

d. Data transformation. A description of the techniques and processes involved in converting the input data into the form required for files or for outputs. This may include a brief description of the mathematical models used.

e. Reports and Displays. A description of each report and display, the frequency and timeliness with which it is required, and the events which initiate its preparation. The description will list the user, content and purpose of the report or display.

f. Queries. A description of query methodology including types of queries, limitations, query flexibility and throughput time.

g. System Capacity Requirements and Constrainst. A

quantitative specification of data volume, the accuracy required, the response time for routine and emergency situations and any limitations which affect the desired capability.

3. Manpower Requirements

a. To establish the data base required to initiate the subsystem.

b. To maintain the data base

c. To operate and maintain the programs

d. To effectively use the capability

APPENDIX C

FINAL DOCUMENTATION OUTLINE

Cover

Title Page

Detailed Table of Contents

I. STAFF MANUAL SECTION

A. SYSTEM DESCRIPTION

A general description of the capability will be provided. It will be oriented towards an audience of users who have no technical background in ADP. This description will specify in layman terms, the usefulness of the capability to the user.

B. SYSTEM INPUTS

1. Staff sources, for data base preparation

a. Identity of source

(1) type

(2) expected volume per unit of time

C. SYSTEM OUTPUTS

1. General description

a. Identity and description of output

(1) type

(2) expected frequency and volume

(3) disposition of output

2. Detailed description

a. Identity of output

(1) Format

(2) Explanation of symbols

(3) Intended use

II. TECHNICAL OPERATIONS SECTION

A. QUERY PREPARATION

1. Method of retrieving information and report generation if a standard retrieval method is not used. Otherwise, a reference to standard methods of retrieval already in use should be given.

a. Query forms (Including formatted creation sheets)

b. Format table

B. SYSTEM OPERATION

1. Console setup and operation

a. General

(1) Computers used

(2) On-line input/output components used such as:

(a) Printer

(b) Card reader

(c) Number and type of tape units

(d) System tapes utilized

(e) Disc

(f) Digital plotter

(g) Display equipment

b. Specific

(1) Details related to above input/output components such as:

(a) Use of on-line printer

(b) Proper arrangements of card decks (deck structure)

(c) Disposition of all output

(d) Instructions for mounting tape, and tape densities (if applicable)

(2) Sense switch settings

(3) Approximate running time

(4) Each separate operation performed should be clearly outlined

2. Description of halts

a. Condition (which caused the halt) NORMAL or ABNORMAL indicates to operator type of error

b. Printout (which will appear with a particular halt)

c. Response (action operator should execute)

3. EAM Procedures

a. Key punch instructions

b. Data sorting and collating instructions

4. Control procedures

a. In-out origin

b. Routing procedures for machine input

c. Responsibilities for control and disposition (cards, listings, etc.)

5. Recommended operators run sheet (an annotated equipment setup summary for operator ready reference)

III. PROGRAM SYSTEM MAINTENANCE SECTION

A. SYSTEM DESCRIPTION

A description of the logical development of the solution by the program and the relationship between routines. The interrelation with other programs is defined. Operating system capacities and restrictions will be defined or referenced.

B. DATA BASE DESCRIPTION

A description of the basic files maintained by and/or for the system.

1. Physical characteristics

size, storage

2. Format characteristics

Item definitions and descriptions, format type

3. Updating

4. Classification

C. DETAILED PROGRAM DESCRIPTIONS

1. Program Title

a. Synopsis

b. Functional description

c. Flow charts

d. Annotated listing

e. Capacities and restrictions

f. Halt and error conditioning

2. Inputs

3. Outputs

4. Internal tables, formats, and techniques

Description of internal tables Modification and updating

COMPOOL

5. Programmer log

IV. APPENDICES

Glossary

Bibliography

Special Additional Information as Needed

Example: Mathematical Proofs

APPENDIX D

DOCUMENTATION SUMMARY

The following is a summary of the documentation to be prepared during the development of an automated system.

A. The Planning Phase

1. System Requirement Documentation prepared by the user.

2. Report of Design Study

Prepared by the Systems Analysts

B. Analysis Phase

1. Development Plan

Prepared by the Systems Analysts and Programmers giving manpower, cost and time phasing estimates for system development.

2. Functional Description

Prepared by the Systems Analysts giving a detailed description of method for automating the system.

C. Development Phase

1. Technical Documentation Manual

Developed in three sections - User Section, Technical Operations Section, System Operation Section and is the basic documentation for operations, maintenance and modification of the system.